Physics 311 - Electromagnetic Theory
Fall 2018
Professor: Dr. Chad Middleton

Classroom	Escalante Hall 325
Class Hours	1:00-1:50 MON, WED, & FRI
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Required Text
Introduction to Electrodynamics, David J. Griffiths, 4th Edition
ISBN-10:0321856562

Course Description
Until the middle of the 19th century, electricity and magnetism were incorrectly thought of as two distinct and separate physical phenomena. In 1820, Hans Christian Oersted noticed that an electric current could deflect a nearby compass needle, implying a relationship between moving electric charges and magnetic fields. Later, in 1831, Michael Faraday discovered that a moving magnet generates an electric current in a wire, thus strengthening the connection between electricity and magnetism. Finally, in the early 1860s, James Clerk Maxwell supplied the missing piece to Ampere's Law, thus intimately connecting electricity and magnetism into one unified *electromagnetic theory*.

These four equations, referred to as Maxwell's equations, plus the Lorentz force law *completely* describe classical electromagnetic theory. In addition to yielding a unified description of electricity and magnetism, Maxwell's equations make the remarkable prediction that light is an electromagnetic wave that moves at a finite speed, with a value precisely determined by two physical constants of the theory! Not only is electromagnetic theory regarded as a crowning achievement of 19th century physics, it also helped lead Albert Einstein to his discovery of the special theory of relativity. The significance of electromagnetic theory cannot be overstated!

This course will largely be a study of:
1. Electrostatics (electric fields generated by charges at rest)
2. Magnetostatics (magnetic fields generated by charges moving with constant velocity)
3. Electrodynamics (electric fields generated by changing magnetic fields, magnetic fields generated by changing electric fields, and the force on a moving charge in the presence of electric and magnetic fields)

From the catalog
"A mature study of electromagnetic fields. Electrostatics and magnetostatics presented. Special techniques, including multipole expansion of fields, analyzed. Electrodynamics introduced leading to Maxwell's equations. Prerequisites: PHYS132/132L, and MATH 260 or MATH 236."
Source: 2018-2019 CMU Catalog, pp. 925

Course Expectations
An undergraduate student should expect to spend on this course a minimum of two hours outside the classroom for every hour in the classroom. The outside hours may vary depending on the number of credit hours or type of course. More details are available from the faculty member or department office and in CMU's *Curriculum Policies and Procedures Manual*.
Electromagnetic theory is inherently mathematical by its very nature. A true understanding of electromagnetic theory will be realized only after you, the student, actually *do* electromagnetic theory (i.e. homework and exam problems). You should treat every homework problem as a test of your understanding of the subject material. The homework sets will

be quite long and will require many hours of work. It will not be unusual for you to spend six hours or more on a homework set. Hard work will be demanded from you in this course!

Course Requirements

Assignments

- There will be roughly one assignment per week consisting of approximately 4-8 homework problems per assignment. Assignments are to be turned in by 5 pm on the date due. Late assignments will be penalized by a 10% grade reduction each day they are late.
- You are encouraged to discuss homework problems with your classmates. Working problems with your peers is an excellent learning method, however, anything turned in **must** be your own work.

Examinations

- There will be four exams during the semester and a *cumulative* final. Each exam will consist of an in-class section and/or a take-home section.

Grading

Your grade for this course is based on the following activities, weighted as shown

Homework Assignments	20%
Exams (4)	60%
Final Exam	20%

Grading Scale:

All graded work will be assigned a numerical score. You may estimate your letter grade by computing a percentage score and comparing it with the table below:

%	Grade
100-88	A
87-79	B
78-70	C
69-60	D
59-0	F

Attendence

Regular class attendance is **strongly** recommended. You are responsible for all material discussed in class. It is in your best interest to *always* attend class and arrive on time - this class begins promptly at 1:00 pm!

Accommodation for Students with Physical and Learning Disabilities:

In coordination with Educational Access Services, reasonable accommodations will be provided for qualified students with disabilities. Students must register with the EAS office to receive assistance. Please meet with the instructor the first week of class for information and/or contact Dana VandeBurgt, the Coordinator of Educational Access Services, directly by phone at 248-1801, or in person in Houston Hall, Suite 108.

Academic Integrity

All incidents of academic dishonesty, including, but not limited to, plagiarism and cheating, will be handled according to CMU policy. For CMU policy on academic integrity, please refer to 2018-2019 CMU Catalog, pp. 86.

Course Catalog

This is a TENTATIVE course calendar ONLY! The actual course can (and most likely will) deviate from the calendar listed below.

Date	Topic
Mon, Aug 20	CH 1 - Vector Analysis
Wed, Aug 22	CH 1 - Vector Analysis

Fri, Aug 24	CH 1 - Vector Analysis
Mon, Aug 27	CH 1 - Vector Analysis
Wed, Aug 29	CH 1 - Vector Analysis
Fri, Aug 31	CH 1 - Vector Analysis
Mon, Sep 3	CH 1 - Vector Analysis
Wed, Sep 5	CH 1 - Vector Analysis
Fri, Sep 7	CH 2 – Electrostatics
Mon, Sep 10	CH 2 – Electrostatics
Wed, Sep 12	**EXAM 1 (Chapter 1)**
Fri, Sep 14	CH 2 – Electrostatics
Mon, Sep 17	CH 2 – Electrostatics
Wed, Sep 19	CH 2 – Electrostatics
Fri, Sep 21	CH 2 – Electrostatics
Mon, Sep 24	CH 2 – Electrostatics
Wed, Sep 26	CH 2 – Electrostatics
Fri, Sep 28	CH 3 – Potentials
Mon, Oct 1	CH 3 – Potentials
Wed, Oct 3	**EXAM 2 (Chapter 2)**
Fri, Oct 5	CH 3 – Potentials
Mon, Oct 8	CH 3 – Potentials
Wed, Oct 10	CH 3 – Potentials
Fri, Oct 12	*Fall Break – No Classes*
Mon, Oct 15	CH 3 – Potentials
Wed, Oct 17	CH 3 – Potentials
Fri, Oct 19	CH 5 – Magnetostatics
Mon, Oct 22	CH 5 – Magnetostatics
Wed, Oct 24	**EXAM 3 (Chapter 3)**
Fri, Oct 26	CH 5 – Magnetostatics
Mon, Oct 29	CH 5 – Magnetostatics
Wed, Oct 31	CH 5 – Magnetostatics
Fri, Nov 2	CH 5 – Magnetostatics
Mon, Nov 5	CH 5 – Magnetostatics
Wed, Nov 7	CH 7 – Electrodynamics
Fri, Nov 9	CH 7 – Electrodynamics
Mon, Nov 12	CH 7 – Electrodynamics
Wed, Nov 14	**EXAM 4 (Chapter 5)**
Fri, Nov 16	CH 7 – Electrodynamics
Mon, Nov 19	*Thanksgiving Break – No Classes*
Wed, Nov 21	*Thanksgiving Break – No Classes*
Fri, Nov 23	*Thanksgiving Break – No Classes*
Mon, Nov 26	CH 7 – Electrodynamics
Wed, Nov 28	CH 7 – Electrodynamics
Fri, Nov 30	CH 7 – Electrodynamics
Mon, Dec 3	CH 7 – Electrodynamics
Wed, Dec 5	CH 7 – Electrodynamics
Fri, Dec 7	Final Review

*****Final Exam:*** *Wednesday, Dec 12 at 1 - 2:50 pm***

Course Learning Objectives:

A student who has taken this course will demonstrate the ability to:

1. Translate between verbal and mathematical descriptions of physical situations. Apply mathematical reasoning, using vectors and vector calculus, to analyze these situations.
2. Apply Coulomb's Law to obtain the electric field of a system of charged particles and extended objects.
3. Compute electrostatic potentials for various charge distributions.
4. Use Gauss' Law to obtain the electric field of various charge distributions.
5. Apply the technique of multipole expansion to arrive at the approximate electric potential at large distances.

6. Use the Lorentz force law to analyze the motion of a charged particle in various physical situations.
7. Apply Biot-Savart Law to obtain the magnetic field produced by various steady current distributions.
8. Use Ampere's Law to obtain the magnetic field of various steady current distributions.

Program-Level Student Learning Objectives:

This course satisfies the following Physics-degree student learning objectives:

1. Articulate the knowledge base and show fluency with the ideas and techniques of the major fields of physics (electromagnetism).
2. Translate physical problems into mathematical problems, solved these using appropriate mathematics and extract physically meaningful statements from the solutions.